TYPE 23 FRIGATE ELECTRICAL DESIGN

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Introduction

The generally accepted reasons for adopting electrical propulsion are:

(*a*) For manoeuvring.

(*b*) So that the main generating plant can be utilized to provide power for auxiliaries in addition to propulsion.

For the Type 23 there is an additional overall reason, namely the ability of providing a system with very low noise characteristics, and with ease of reversing without the complication of controllable-pitch propellers or reversing gearboxes. Other reasons are flexibility of layout and control and optimization of the number of prime movers to suit load demand.

Since the electrical drive has to provide manoeuvring power as well as propulsion power, it is necessary for the two electric motors to be independently controlled and capable of supplying full power in either direction of rotation. The electric motors could be either a.c. or d.c. machines provided the requirements for independent control are satisfied.

Selection of the system configuration, rating of equipment, mode of operation and control have all been influenced significantly by the requirements of the electrical motors, as they are by far the largest loads as well as having operational features. Many detailed studies were undertaken during concept and feasibility, covering total system requirements including electrical propulsion and electrical main supply system. A.c. and d.c. propulsion schemes were each considered with integrated and split configurations.

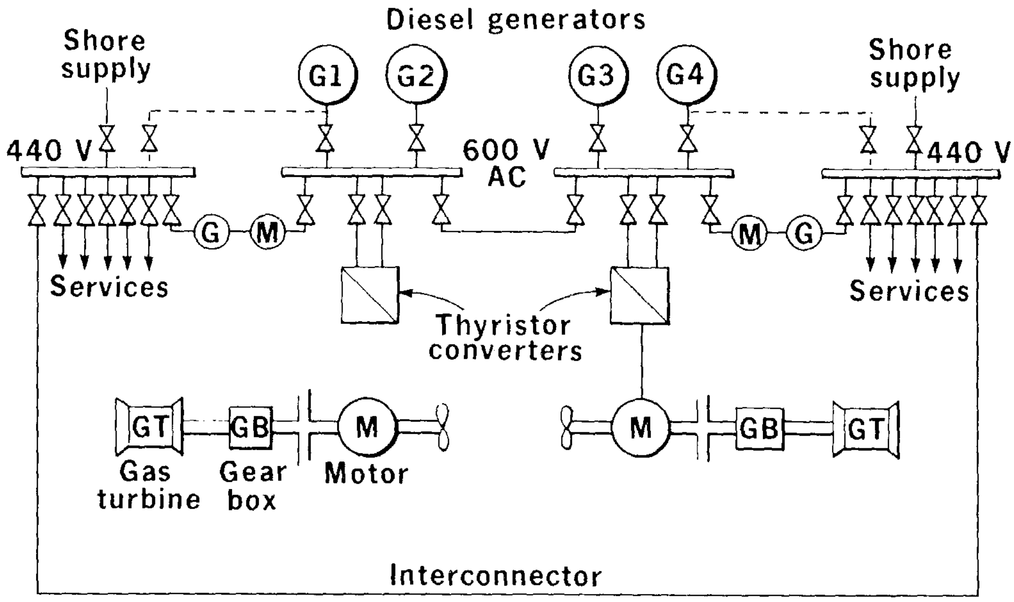

FIG. 1—TYPE 23 MAIN SUPPLY SYSTEM

The selected system (FIG. 1) is based on the integrated type. i.e. main supply electrical propulsion systems that are fed from the same four diesel generator sets, which form a central power supply for the ship as a whole. This has enabled a 600 V, 60 Hz, 3-phase a.c. system to be used, with continuous parallel running, two switchboards, and a single main interconnector.

The ship's electrical supplies are at 440 V, 60 Hz, 3-phase, derived from two motor-generator sets. The two switchboards will be composite boards accommodating the 600 V primary breakers and the 440 V distribution breakers and equipment. Variable d.c. electrical propulsion motors were finally chosen, with thyristor-control inverter drive.

Advantages of integrated system configuration

The integrated system configuration has the following advantages:

(*a*) Minimizes the number of diesel prime movers required.

(*b*) Gives best utilization of generating capacity.

(*c*) Allows economic continuous low-speed ship operation.

(*d*) A certain amount of power is always available for crash stopping when on gas turbine drive.

The main disadvantage of the integrated system is the need for large motor-generator sets to provide power supplies to the normal R.N. quality standard.

System operating voltage

600 V is a non-standard R.N. voltage but its use offers attractive savings in equipment cost and volume. In particular, the converter utilizes thyristors which are quite capable of operating at higher voltage, thereby reducing the number of cells required to handle the current. This and other current-related components would basically require a 36% higher rating and volume (and weight) if operated at only 440 V. Operation at 600 V with two motor-generator sets allows four diesel generator sets to be operated in parallel within the full rating capacity of the switchgear.

Quality of power supply: harmonic distortion and EMC

Thyristor control of the d.c. propulsion motor produces a large amount of voltage waveform and harmonic distortion. The amount of distortion is related to the number of generator sets operating and the propulsion motor load, and grossly exceeds the permitted limits quoted in the R.N.'s normal standards specification for power supplies. Additionally, the rapid switching of the thyristor circuits in the propulsion motor power controls can be expected to produce high levels of radio frequency interference. It is intended to suppress this at source to meet the specification for interference limits.

Initially it was considered that the problems of electromagnetic compatibility (EMC) and, to some extent, waveform distortion could be tackled by filtering and screening at the source of the interference. It was acknowledged, however, that the solution of the EMC problem is not easily amenable to calculation, so a solution with minimal risk to the ship design was the only one that could sensibly be pursued. The chosen solution is to supply all ship's loads with power at 440 V, 60 Hz, 3-phase derived from motor-generator sets, the motor-generator sets giving isolation from electomagnetic interference (EMI) and providing supplies to meet the R.N. requirements for quality of power.

Switchboards and distribution systems

There are two composite switchboards in the Type 23 frigate, operated both at the primary system voltage of 600 V and the main electrical supply voltage of 440 V. A considerable amount of system engineering thought was given to this power system in arriving at the chosen voltage and the air circuit breaker selection. The same air circuit breaker has been chosen for both the 600 V and 440 V operation, thereby ensuring component commonality, with considerable logistic, training and documentation advantages which overall make for a cheaper switchboard and lower through-life costing.

Electrical power supplies at 440 V, 60 Hz, 3-phase will be derived from the two motor-generator sets; supplies will be distributed from the main switchboards at 440 V via MCCBs to EDCs. The motor-generator sets are sized such that the ship's essential load can be supplied from one set in an event of failure in the other. The size of the motor-generator sets also ensures that the ship's service motors can be started direct on line. It is intended that, wherever possible, each EDC will supply a functionally identifiable group of loads. Ideally, this will allow the effect of loss of the supply to an EDC to be assessed quickly. However, this requirement must be judged against the need to site the EDC as close as possible to the centre of the area of load and thus keep distribution cables downstream of the EDC to a minimum length.

Propulsion motors

The propulsion system in the Type 23 is twin-shaft CODLAG with each shaft set comprising a single SM1A gas turbine, reduction gearbox and clutch, and with an in-line d.c. propulsion motor directly driving a fixed-pitch propeller. This represents the main propulsion of the ship as electrical propulsion, with a gas turbine sprint capability. Conventional d.c. motors were chosen for the electrical propulsion on the basis of being the best-developed from the noise aspect, offering the most flexible control of torque/speed characteristic, smoothest low-speed running, best low-speed torque, and utilizing smaller and less complicated converters. A.c. motors offered no clear advantage and would involve a considerable risk, particularly in the converter/motor development area.

The disadvantage with d.c. motors—of additional maintenance for the commutator and brush gear—is far outweighed by the many advantages.

System operation

The diesel generator sets will be operated with up to four continuously in parallel via the primary interconnector, to provide propulsion power and electrical power supplies. The number of sets to be operated will depend on the ship's electrical load and the required speed. The loaded generator sets will run independently of each other to supply the respective distribution switchboard sections, each set capable of maintaining the ship's essential load in the event of failure of one set.

Automatic load-shedding circuits will be used to reduce propulsion power and non-essential ship's services in the event of a diesel generator failure or trip when the ship is on electric drive. Automatic load-shedding will also be available for other operational scenarios.

The electrical main supply system will be designed for continuous parallel operation with adequate protection equipment to detect and isolate a failing diesel generator set.

System control

The electrical main supply and propulsion system will be operated from the ship control centre and routine tasks, such as diesel generator start-up, synchronizing and parallelling of the generator sets, will be automated. Because the system is designed for continuous parallel operation, the task of system management becomes relatively simple and will remain under the control of the watchkeeper in the ship control centre. There will be a considerable degree of automation in the Type 23 but the full extent has not yet been finalized. Considerable diagnostic information will be displayed via a secondary surveillance system.

Reversionary control of the system will be possible at the secondary control positions.

Reference

1. Scott, A. J.: Electrical system design for warships; *Journal of Naval Engineering,* vol. 28, no. 1, Dec. 1983, pp. 86-106.
